MONTANA WATER CENTER

Annual Report
Fiscal Year 2005

September 2005

Montana Water Center

The Montana University System Water Center, located at MSU-Bozeman, was established by the Water Resources Research Act of 1964. This act created and funded Water Resources Research Institutes at land grant universities in 54 states and territories. The mission of the Montana Water Center is to investigate and resolve Montana's water problems. It does this by sponsoring water-related research, fostering the education of future water professionals, and providing outreach to water professionals, water users, and communities.

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The Huffman Building on the Montana State University campus.

MONTANA WATER CENTER

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COVER PHOTO:

The original photo (left) was taken by Justin West, Computer Software Engineer, Montana Water Center. It was taken at St. Mary's Lake in Glacier National Park.

While it dealt with water in many bills, the signature water measure of the 2005 Montana Legislature was House Bill 22. The effect of this bill will be to accelerate examination of claims and the adjudication of water rights in the many basins where rights have not yet been decreed. The adjudication process has been moving forward slowly for more than 20 years; HB 22's bolstering of resources for the process is a welcome development for many rights-holders throughout the state.

The establishment of the right to divert water, in what quantity, for what purpose, and at what place and time, is only one aspect of a very complex water puzzle in our state. Those who live in basins that have already been adjudicated know that this only resolves a small fraction of their difficulties. Many, possibly most, of the watercourses that have been adjudicated are over-appropriated; that is, there is not enough water in the streams year-round to satisfy all valid claims. Our chronic drought of recent years has exacerbated this shortage. 'In-stream' water uses, where water is left in the stream to sustain fisheries and riparian resources, have increasing importance, effectively boosting the demand for water. Changing land uses affect surface water and ground water and the relation between the two, but the changes are watershed-specific and difficult to predict. Finally, the climatic regime on which our physical and institutional water infrastructure is based has changed. Spring comes earlier and fall comes later than 40 years ago. This two-week lengthening of the 'green season' has been documented over the entire northern hemisphere. And so, precipitation from these seasons that was once conveniently stored as mountain snow pack, then released by snowmelt during the irrigation season, instead falls as rain and runs off the land.

All of this means a continued demand for Montana Water Center projects and products. Good science is needed for better understanding of the water domain and for better prediction of affects and changes. Vigorous outreach that makes the results of the science accessible and meaningful to Montanans is also needed. Education and training for future water professionals is a continuing and, perhaps, an increasing need. This report summarizes how the Montana Water Center pursued research, outreach and educational activities during fiscal year 2005 (July 2004 - June 2005).

PROGRAM HIGHLIGHTS

Fisheries Health. Since 1997, the *Whirling Disease Initiative* has sponsored more than 100 research projects on topics ranging from epidemiology to the genetics of the aquatic worm that hosts the whirling disease organism. A great deal of data has been collected. This year we began a project to compile the data from individual investigators into a centralized database. This will facilitate higher-level analyses of disease attributes and trends. The U.S. Geological Survey and the Big Sky Institute of MSU are assisting with the data compilation. An independent expert panel has just submitted recommendations on the questions that the Initiative should now be pursuing. Compared to the past, these questions are larger in scale, broader in scope

and of longer duration. This past year also saw the initiation of a vigorous program of outreach concerning whirling disease. The principal audience is fishery managers in the western states, but this program also serves other audiences, such as anglers.

Under the aegis of the *Wild Fish Habitat Initiative* several graduate and undergraduate students conduct research that will contribute to the sustenance of wild fish populations or support re-introduced fish in restored stream habitats. In the Bitterroot valley, students collaborated with private landowners and irrigators to optimize devices that keep fish from being diverted into irrigation canals. In southeastern Montana, other students investigated the positive and negative impacts on native fish populations when coalbed methane product water is discharged into watercourses. Still others documented the successes and failures of artificial in-stream barriers to protect native fish populations from predaceous and competitive non-natives in many watersheds, and defined the water temperatures where cutthroat trout flourish. This research initiative is a collaborative effort involving the federal government (U.S. Geological Survey, U.S. Fish and Wildlife Service, and Montana's Congressional delegation), Montana State University, the Water Center, and citizens of Montana, working together to solve on-the-ground problems for the betterment of our environment and our economy.

Drinking Water. *Operator Basics 2005* was completed this spring. This is a package of three interactive training courses for the operators of small drinking water and wastewater systems. Taking into account our earlier curricula on which *OB 2005* is built, this represents the largest single project in the history of the Water Center. The courses can be run from the Internet, downloaded, or run from CD-ROM. They include more than 20 hours of training, and are augmented with tests, math tutorials, resource contacts for operators in every state, and a sizeable technical glossary. First-time operators can use these materials to train for their certification exams, and working operators can use them to accrue continuing-education credits. Although the Water Center pioneered this distance-learning approach for operators who serve rural Montana communities, it has proven to be very widely popular. Nationwide, over 20,000 CD-ROMs of *Operator Basics 2005* have been distributed.

Water Information and Services. This year we organized the annual meeting of all 54 university-based Water Resources Research Institutes, which took place in Washington, D.C. in March. At a busy time in the legislative calendar, Senator Conrad Burns found time to address the gathering, sharing his observations on the importance of research to improve the lives of ordinary citizens. The Institute directors traded their experiences fostering water research, outreach and education in their states, and heard from administration officials concerning current work to coordinate water research and water policy at the highest levels of government. They also received updates on national research initiatives, and paid calls to their respective Congressional offices. All in all, it was a busy and invigorating get-together.

INSIDE THE WATER CENTER

We experienced a wonderful organizational change this summer, consequent on the National Watercourse leaving Montana State University to become a private foundation. The *Montana Watercourse*, an adjunct of the national program, joined the Water Center. The programs it operates—both adult water education and K-12 student programs such as Project WET Montana—perfectly complement the outreach to water professionals that has been a specialty of the Water Center. Note that the Water Center mission statement printed in this report is broader than it was last year! We're very pleased to welcome to our team: Debbie Zarnt, Community Outreach Coordinator; Frances Moore, Education Outreach and Project WET Coordinator; Janet Bender-Keigley, Office Manager; and Karen Filipovich, Director of

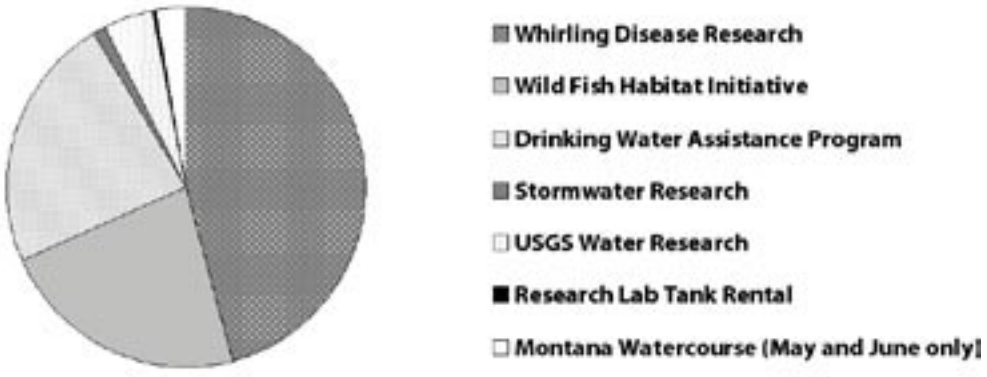
the Montana Watercourse. The only unfortunate aspect of this change is geographic. MSU space constraints dictate that, in the near term, Montana Watercourse personnel will continue to be housed in Culbertson Hall, at the opposite end of campus from the rest of the staff.

This year we were finally able to install an emergency generator to power the *Wild Trout Research Laboratory* in the event of a prolonged power outage. In addition, we've developed plans for a lab renovation that will render the facility useful to a much broader array of research clients than it currently serves. This summer Cal Fraser, who had served as Laboratory Manager for its entire eight-year history, accepted a position outside the University. Trey Kucherka, a mariculture specialist from Texas, has just accepted the position of Laboratory Manager. Trey will operate the Wild Trout Research Laboratory and oversee its renovation, and he'll serve as a project Biologist with the Wild Fish Habitat Initiative.

Barb Coffman left us this summer. Barb was our Drinking-Water Specialist who telecommuted to the Water Center very smoothly from offices at MSU-Northern in Havre. Later this summer, we engaged Ben Cichowski as our new Water Specialist. Ben is a biologist and engineer from Texas A&M University. This year his main responsibility is to develop curriculum for our "next generation" of interactive drinking-water courses.

The Water Center is funded principally by grants from federal and state agencies. It also receives modest foundation funding, and collects fees for use of the Wild Trout Research Laboratory. In summer 2005, the Whirling Disease Foundation gave a special grant to the Center for recruitment of the new Lab Manager. Our fiscal year 2005 budget was $2.4 million, allocated as shown in Figure 1.

Figure 1. Montana Water Center Fiscal Year 2005 Budget



This year our projects supported 35 undergraduate and graduate students through research assistantships, and 13 students through our new fellowship program. We served as the sponsoring organization for 51 research grants, of which 32 were conducted at Montana universities. How are we doing? We work for the people of Montana, and we're always keen to learn how water issues affect you, and how the university system, working through the Water Center, might be of help. I invite you to contact us at any time.

Best regards,

Gretchen Rupp

Gretchen Rupp, Director

September 2005

WHIRLING DISEASE INITIATIVE

Enabled by a 1997 Act of Congress, the Whirling Disease Initiative sponsors research to battle the whirling disease problem. The National Partnership for the Management of Wild and Native Coldwater Fisheries, a consortium of agencies and organizations concerned with the status of wild and native fisheries in the United States, provides oversight. The Partnership convenes annually with scientists who serve on the Initiative's Whirling Disease Steering Committee. Staffed and administered by the Montana Water Center, the Initiative solicits and selects projects for funding following scientific peer review, distributes research results, and coordinates outreach activities. Each year, federal funding earmarked in the Interior Appropriations Bill comes to the Initiative through the Division of the National Fish Hatchery System of the U.S. Fish and Wildlife Service.

More than 100 whirling disease research projects have been carried out since 1997. More than $8 million of federal and matching funds has been expended or committed by these projects. Typically two-to-four investigators guide each project, contributing cash or in-kind match to the project amounting to 25 to 150 percent of the amount of the federal grant. Most projects employ student technicians and graduate research assistants. Summaries of all past research projects can be found at the Initiative's web site: http://whirlingdisease.montana.edu.

This year's annual meeting of the National Partnership Board was held in Bozeman in September, 2004. The meeting focused on risk assessment of whirling disease in streams, potential management strategies, and the status of the disease in the western states. Initiative topics receiving special scrutiny were the establishment of a central project-results database, the new outreach program, and re-evaluating the goals, processes, and objectives of the Initiative.

The microscopic parasite that causes whirling disease in many salmonid fish species has spread and infected hundreds of river reaches throughout the United States. Its impacts on susceptible trout can be dramatic: darkening of the tail, skeletal deformities, frenzied tail chasing (thus the name "whirling" disease), and death. The whirling disease parasite is extremely hardy and long-lived. Its life cycle is dependent on two distinct hosts—salmonid fishes and the aquatic worm, *Tubifex tubifex*. Understanding the parasite has required intense study of the biology of infected fish, infected worms, and the parasite spore stages.

A Eurasian native, *Myxobolus cerebralis* made its way to North America in the 1950s. Once thought harmless to wild fish, research in the mid-1990s found that it was infecting rainbow trout populations in some of the Rocky Mountain region's finest river fisheries. Most salmonids have been found to be susceptible, making whirling disease a threat to biological diversity and to the nation's multi-million-dollar fishing and tourism economy. The parasite has been reported in 23 states—from New York to California—and has generated great concern among anglers, scientists, and fisheries managers.

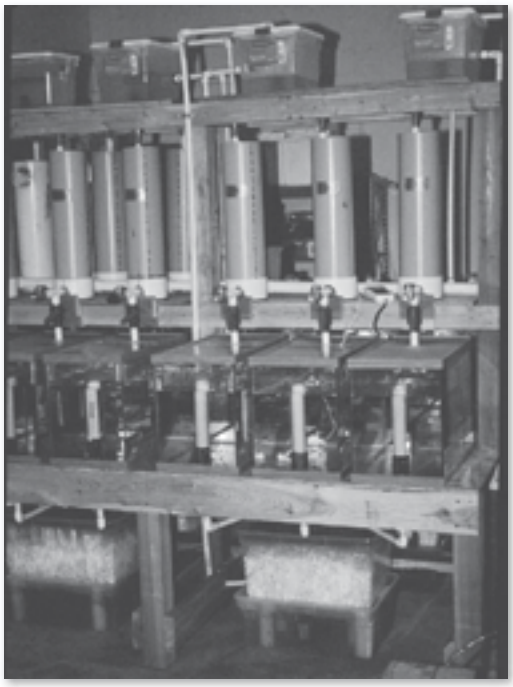
2003-2004 Research Projects

During the cycle ending in December 2004, eight research projects were funded with a total of $557,585 in federal dollars, leveraging an additional $516,270 in match from collaborators. Research teams included 24 investigators from seven states.

Evaluation of quantitative real-time PCR for rapid assessments of the exposure of sentinel fish to *Myxobolus cerebralis*. Mark A. Adkison and Ronald P. Hedrick, University of California-Davis. Several rapid and sensitive methods for detecting DNA or RNA of *M. cerebralis* in fish have been developed in this team's laboratory. These include two TaqMan quantitative real-time polymerase chain reaction (qPCR) assays, a nested PCR, and a single round PCR all with the 18 S rDNA or the rRNA gene as the target sequences. In this study, researchers compared the sensitivity and specificity of these tests on rainbow trout at three intervals (10 days, 67 days, and 5 months) following experimental exposures to triactinomyxons (TAMs) of *M. cerebralis*. They also examined two conventional assays—histology at 67 days and 5 months, and the myxospore detection by pepsin trypsin digest at 5 months—on the same fish used for the PCR assays. In addition, they studied the potential for the 10-day qPCR assay as a predictor for the infection status of fish from the same population sampled later at 67 days and 5 months post exposure to *M. cerebralis*. Not only did the study develop sensitivity ratings for all methods, results show qPCR analyses at 10 days are a useful indicator of the proportion of fish that will be infected in the population at a later time. This may preclude the standard field monitoring or sentinel study protocol to hold fish for periods of up to 2 or 5 months before evaluating their infection status following natural exposure to *M. cerebralis*.

Effect of riparian zone and associated stream substrata on *Tubifex tubifex*: density and infection rate with *Myxobolus cerebralis*. Deborah Cartwright, Vicki Blazer, and W. Bane Schill, U.S. Fish and Wildlife Service Research Laboratory, Leetown, West Virginia. This study evaluated whether leaf litter substrate from the riparian zone can affect the density of *T. tubifex*, and the ability of resident worms to become infected with *M. cerebralis* spores and release infective spores. Few studies have addressed environmental effects (other than temperature) on *T. tubifex* populations. Results of previous studies found that sites dominated by a deciduous riparian zone had a low percent of *T. tubifex* within the oligochaete benthic population. Within that population was a low percentage of lineage III worms—the only lineage researchers found to be infected. Thus, it is possible that particular environments may select for certain lineages that differ in susceptibility to *M. cerebralis* infection. Laboratory studies support this. They also suggest factors other than substrate may affect infectivity and viable TAM production at some sites. Hence, the research team will further evaluate the oligochaete populations and water quality at these sites. In addition, laboratory exposures will evaluate the ability of *T. tubifex* from the individual sites to be infected in a reference substrate (sand), and determine if differences in infectivity are observed in similar lineages from different environments. Most importantly, they will determine which genes are used during the development of *M. cerebralis* within *T. tubifex—genes* that might affect infection—possibly producing non-viable TAMs or lack of development in certain lineages/strains.

Development of molecular markers linked to whirling disease resistance in rainbow trout. Eric Wagner, Chris Wilson, Karen Mock, and Mark Miller; Utah Division of Wildlife Resources and Utah State University. Histological score data for the Fish Lake-DeSmet (RTFD) strain of rainbow trout, *Oncorhynchus mykiss*, indicate that some resistance to *Myxobolus cerebralis* was present in a Montana Harrison Lake study. This led to follow-up exposure studies in Montana and at Utah State University. The Utah team also worked to identify genetic markers that differentiate genotypes of resistant and susceptible individuals to whirling disease. In analyses of genetic diversity patterns,



Exposure studies on rainbow trout.

results indicated significantly reduced variation among resistant fish, a result that is consistent with recent strong natural selection for whirling disease resistance within the population. The research team suggests that disease susceptibility may currently be maintained in this population as a result of demographic processes. Their analyses indicate that the panel of markers generated in this study may be useful for identifying resistant and susceptible adults within the Harrison Lake rainbow trout population. Ultimately, they may permit development of captive populations of this strain that facilitate future research on the genetic basis for disease resistance in salmonids.

Analysis of non-lethal techniques for detection of *Myxobolus cerebralis*. Molly (Toner) Bensley and Linda (Staton) Beck, U.S. Fish and Wildlife Service, Bozeman, Montana. Often, thousands of fish must be sacrificed to identify *M. cerebralis*-positive waters in field investigations. The goal of this project was to provide rapid, non-lethal, economical, and highly sensitive DNA techniques for field application. Bensley and Beck set out to determine if the PCR assay for *M. cerebralis* in non-lethal tissue samples can detect the parasite after only brief fish exposures in a stream environment, and to develop a rapid diagnostic field test. Studies were preformed utilizing DNA-based diagnostic approaches to detect *M. cerebralis* at 24 hour and, 1, 2, 3, 5, 7, 9, and 11 months post-exposure to various doses of triactinomyxons in laboratory and naturally-exposed rainbow trout *Oncorhynchus mykiss*. Results show that samples collected from fish naturally exposed for 24 hours is sufficient to detect *M. cerebralis, provided* that the exposure is during periods of potential infectivity in that river system. Furthermore, nested PCR on fin tissues or skin scrapings, collected individually or pooled, proved to be an accurate, non-lethal assay for the detection of *M. cerebralis* at 24 hours or one-to-three months post-exposure. These improved techniques can facilitate early assessment of *M. cerebralis* infections in the most susceptible trout life stages—a real benefit to managers facing complex risk management decisions involving infected fish, either in culture or free-ranging environments.

Assessing non-lethal techniques for detecting the parasite.

Testing impacts of channel modifications to reduce *T. tubifex* habitat. Dana Winkelman, Terry Waddle, Kevin Thompson, and Jim Terrell; Colorado Cooperative Fish and Wildlife Research Unit, USGS Fort Collins Science Center, and Colorado Division of Wildlife. Using information from a channel bed survey and a hydraulic simulation model of Willow Creek, Colorado, this team set out to predict changes in *T. tubifex* habitat at a site on the Poudre River, Colorado. They developed a set of flow scenarios and channel configurations that create the least amiable habitat for tubifex survival. They established a benchmark for Willow Creek—a well-drained, open site with excellent satellite signal reception. The Poudre River benchmark had a less ideal location where eventual deterioration is expected. Both monuments allow for monitoring and assessment of small changes in channel morphology and oligochaete habitat. Channel topography models were used to design habitat improvement at each site. Although verification of post-construction conditions compared to model predictions was hampered at both study sites by beaver dam construction and drought conditions, data and modeling indicate that *T. tubifex* habitat may not experience sufficient flow to move fine sediment during normal spring flows. In the Poudre River, it is likely that portions of the fine material mobilize and re-deposit annually. Triactinomyxon (TAM) monitoring at Willow Creek had limited usefulness for evaluation because few spores were observed in the samples. In addition, TAM densities do not differ much at the Poudre River monitoring sites. However, TAMs were observed with greater frequency on the Poudre River and continued monitoring is recommended. Lineage analyses before and after habitat modification in Willow Creek suggest that the proportion of lineage III DNA in the worm samples decreased after habitat modification; however it is unknown if the modification caused this decline. Lineage III also declined in the Poudre River before any habitat modification, suggesting that another mechanism may be responsible.

Evaluation of management actions to control the spread of *Myxobolus cerebralis* in a lower Columbia River tributary. Jerri Bartholomew and Antonio Amandi, Oregon State University. This study in Clear Creek, Oregon first determined if *M. cerebralis* had become established in the lower Willamette River basin as a result of its introduction in a small private hatchery. It then determined if the parasite was likely to be reintroduced if eliminated from Clear Creek. The inability to detect infection in sentinel fish exposed above the hatchery at any time following its closure indicates that the parasite has not become widely established in Clear Creek and that the hatchery may be the source of infection for fish downstream. The detection of *M. cerebralis* six miles below the hatchery nine months after hatchery closure indicated that either an additional population of infected host worms exist, or that parasites continued to be released from the hatchery. However, infection has not been detected in sentinel fish held below the hatchery since December 2003, although the hatchery contains *T. tubifex* that remain infected. Survey of oligochaete worm populations in Clear Creek identified *T. tubifex* only in sediment from the hatchery and from the mouth of the river mainstem. Genetic analyses revealed these worms were of the two known susceptible lineages—no resistant lineages were found. TAMs were found only in water samples from the hatchery. These data indicate a low risk of establishment of the parasite outside the hatchery as a result of introduction by anadromous fish. However, the hatchery itself continues to be a risk to the system as long as infection persists. Continued closure of the hatchery is necessary until the sediment can be safely removed from the facility. Continued surveillance of stray anadromous salmon will provide information on the likelihood of future introductions into the system.

Epidemiology of whirling disease: an integrated study of the Rock Creek drainage, Montana. Willard O. Granath, Michael Gilbert, Billie Kerans, and Eric Reiland; University of Montana, Montana State University, and Montana Fish, Wildlife and Parks. One of the longest investigations to date, Dr. Granath's study has looked at the evolution of the whirling disease infection in the Rock Creek drainage of Western Montana since 1998. His team has assessed the overall epidemiology of whirling disease throughout this ecosystem including the relationship of *M. cerebralis*-infected *T. tubifex* to infection rates and severity of whirling disease in trout. Results indicate that infected *T. tubifex* are found throughout the drainage, but they are present in much greater numbers and are more widely dispersed in areas with degraded riparian habitat. Trout become infected at many locations where infected *T. tubifex* have not been recovered, and it is possible that the fish at some of these sites had been infected by parasites originating hundred or even thousands of meters upstream. Infection rates in sentinel fish have increased throughout the course of this study, and the range of *M. cerebralis* within the Rock Creek drainage is still expanding—more than six years after its initial detection. This is a significant finding, since no type of timeline concerning the spread of whirling disease after the introduction of the parasite into a drainage had ever been established. Preliminary data did not reveal a correlation between localized streamflow and the severity of infection in sentinel fish. However, total water flow still appears to affect the severity of disease, as an apparent dilution effect on TAMs was observed in the upper portion of the drainage. This study also examined the genetic homogeneity of *T. tubifex* using randomly amplified polymorphic DNA (RAPD). Analyses indicate presence of at least three distinct genotypes of *T. tubifex* within the Rock Creek drainage, with one of these (genotype A) being the most dominant. Additional molecular markers are being employed in an attempt to differentiate susceptible and non-susceptible genotypes of *T. tubifex*.

Development and testing of risk assessment tools for *Myxobolus cerebralis* infection of native cutthroat trout in Yellowstone National Park. Billie Kerans and Todd Koel; Montana State University and National Park Service. Kerans and Koel examined the risk of whirling disease infection to Yellowstone cutthroat in Yellowstone National Park. They first examined cutthroat trout risk in three intensively studied streams using sentinel fish enclosures, wild age-zero trout, and

Sentinel cage on Pelican Creek.

tubificid assemblages. They then examined the physical and chemical features of these three streams. Results show that the parasite-infected sentinel fish in two of the intensely-studied Park streams, Pelican Creek and Yellowstone River. All four locations in Pelican Creek were positive for the parasite, whereas three of six locations on the Yellowstone River were positive. In one of three locations on Pelican Creek and two of five locations on the Yellowstone River—where wild age-zero cutthroat trout were found—the fish were positive for *M. cerebralis*. Tubificids positive for *M. cerebralis* were found in Pelican Creek as well. Physicochemical characteristics differed among the three reaches; conductivity was highest in Pelican Creek and lowest in Clear Creek. Infection was not detected in extensive sentinel cage studies of several other tributaries to Yellowstone Lake. The research team is currently applying results to a qualitative risk assessment model to help fish biologists and managers reduce disease risk.

2004-2005 Research Projects

The Steering Committee selected twelve new projects for funding in the 2004-2005 research cycle. A total of 29 investigators from five states are involved. Grant awards total $676,990 and match funding amounts to $343,870. Nine projects got underway on May 1, 2004; two additional research projects commenced on July 1, 2004; and one project started on January 1, 2005. These projects will conclude on December 31, 2005.

Susceptibility of Rio Grande cutthroat trout *Oncorhynchus clarki virginalis* to experimentally induced infection with *Myxobolus cerebralis*. Colleen Caldwell and Robert DuBey, New Mexico State Univeristy. The purpose of this study is to define the nature of the susceptibility of Rio Grande cutthroat trout *Oncorhynchus clarki virginalis* (RGCT) to infection by *M. cerebralis*. Presently, RGCT occupy a fraction of its presumed historic range, and is considered "at risk" by the New Mexico Department of Game and Fish and "imperiled" by the U.S. Fish and Wildlife Service. If *M. cerebralis* were to spread to genetically-isolated populations of RGCT, they would be at great risk of infection. Increased disease susceptibility of several cutthroat trout subspecies when compared to rainbow trout has been demonstrated using sentinel fish. This study will use a controlled laboratory approach with a suite of diagnostic metrics to provide a quantitative estimate of susceptibility for RGCT. Metrics will include mortality, clinical symptoms, histology, and DNA diagnostics of *M. cerebralis* (nested PCR) in both RGCT and rainbow trout. Accurate assessment of RGCT susceptibility will allow fisheries management agencies to formulate risk management strategies to mitigate this devastating infection.

Assessment of the risk of *Myxobolus cerebralis* introduction as a result of straying adult steelhead and spring Chinook salmon in the Columbia River Basin. Jerri Bartholomew, Antonio Amandi, and Susan Gutenberger, Oregon State University. A critical unknown for managing anadromous fish is whether the straying of infected adult fish plays a role in the introduction of *M. cerebralis* and other pathogens to new areas. This project assesses the role of straying adult steelhead and spring Chinook salmon in disseminating *M. cerebralis* in the Columbia River Basin (CRB). It expands on previous work in the CRB: studies on the effects of *M. cerebralis* on anadromous salmonids in the upper CRB, risk management assessments conducted on the Deschutes River in the central CRB, and current investigations on establishment of the parasite in a tributary of the lower CRB. Objectives are to: (1) estimate the frequency of adult salmonids straying into tributaries of the lower and mid-Columbia River, (2) determine the proportion of these fish infected with *M. cerebralis*, (3) develop estimates of introduction risk for these tributaries, and (4) determine infection efficiency under differing *T. tubifex* densities, susceptibilities, and under different flow regimes using a laboratory model.

Determining the presence of whirling disease in the CRB.

Evaluation of increased survival of young-of-the-year wild rainbow trout in the upper Madison River in the face of increased whirling disease infection intensities in wild rainbow trout spawning areas. Patrick Clancy and Billie Kerans; Montana Fish, Wildlife and Parks and Montana State University. Whirling disease is still a serious problem in the Madison River of Montana. From the disease's onset in 1990, the recruitment of young wild rainbow trout into the fish population of the upper Madison River has been compromised. This study will determine if:

- wild rainbow trout in the Madison River are beginning to develop some resistance to severe infections by *M. cerebralis*;
- resident wild rainbow trout in the upper Madison River have changed primary spawning, hatching, and rearing locations from the sites utilized in 1998-99;
- wild rainbow trout resident to the upper Madison River are spawning earlier or later than in 1998-99, when the potential for high infection rates of hatching and emerging young rainbow are less likely to occur; and
- there has been a change in the rate or level of infection of *T. tubifex* worm populations in side channels that were used by spawning rainbows in the late 1990s.

Sorting through samples on the Madison River.

Non-lethal testing for *Myxobolus cerebralis* infection by Enzyme Linked Immunosorbent Assay (ELISA). Mark Adkison, Ronald Hedrick, and Garry Kelley, University of California-Davis. This study will determine the sensitivity and specificity of a non-lethal ELISA assay for the detection of *M. cerebralis* infections in fish. Current methods require killing the fish in question. The ELISA assay detects the antibody against *M. cerebralis* in trout serum, which can be collected without harming the fish in question. Moreover, the project will determine how early researchers can consistently identify infected fish by measuring anti-*M. cerebralis* antibody (Ig) in their serum. Confident in the sensitivity of the ELISA assay itself, researchers will attempt to determine the lowest detection limit when fish produce *M. cerebralis* antigen-specific Ig. They also want to test the hypothesis that triactinomyxon lysate antigens are sufficient to measure Ig produced at all infection stages.

Forensic applications of otolith microchemistry for tracking sources of illegally-stocked whirling disease positive trout. Brett Johnson, Patrick Martinez, Dana Winkelman, and Gregory Whitledge; Colorado Division of Wildlife and Colorado State University. Maintenance of self-sustaining wild and native trout fisheries is jeopardized by the spread of whirling disease. The extent to which illegally-stocked, whirling-disease positive fishes have contributed to this spread has been difficult to assess. This study will develop a method for determining origins of illegally-stocked, whirling disease-positive trout through microchemical analysis of otoliths. The researchers are developing otolith microchemistry techniques for determining origins and movement patterns of nonnative fishes in the Colorado River Basin. This research has three primary components aimed at: (1) determining the geographic resolution based on chemical signatures of otoliths and water samples from Colorado state hatcheries, (2) assessing the utility of these signatures for tracing hatchery origins of fish at large, and (3) determining variation in microchemical fingerprints and isotopic signatures of otoliths obtained from select private hatchery fish, and assessing the utility of these signatures for tracing hatchery origins of fish at large.

***Myxobolus cerebralis* in a pristine environment: The role of American white pelicans as a dispersal vector in the Greater Yellowstone Ecosystem. Todd Koel and Billie Kerans; Yellowstone National Park and Montana State University.** The whirling disease parasite is prevalent in native Yellowstone cutthroat trout *Oncorhynchus clarki bouvieri* throughout Yellowstone

Lake. Infection severity is extremely high in Pelican Creek, the second largest cutthroat trout spawning tributary and a common foraging stream for American white pelicans *Pelecanus erythrorhynchos*. Dissemination of *M. cerebralis* in the region is blamed primarily on movement of infected fishes by humans. However, no fishes have been (legally) transported to the waters of the Yellowstone Lake basin or in many places elsewhere in Wyoming where the parasite now exists. In the Yellowstone Lake ecosystem and elsewhere, white pelicans are feeding, moving among waters, and defecating. Unknown is the potential viability of any defecated *M. cerebralis* myxospores. The goal of this study is to determine the potential of American white pelicans as a dispersal vector for *M. cerebralis*. Specific objectives are to: (1) examine white pelican feces for the presence of *M. cerebralis*, and (2) determine if any defecated myxospores are capable of infecting *T. tubifex* resulting in viable *M. cerebralis* triactinospores. Results will provide some of the first information on the potential of a common avian piscivore to spread *M. cerebralis* among waters of the western United States.

Movements of resident and non-resident anglers in Montana: Implications of transferring whirling disease among drainages. Christopher S. Guy, Alexander Zale, and Travis Horton; Montana State University, Montana Cooperative Fishery Research Unit. Despite the numerous studies on the biology of *M. cerebralis*, little is known about its transfer among drainages by anglers. It is likely that anglers can transfer *M. cerebralis* because myxospores are found in the sediment, fishing equipment captures benthic sediment, and anglers are mobile. To respond to this question, the Whirling Disease Initiative solicited a multi-year angler vector study headed by Dr. Chris Guy, Assistant Unit Leader, U.S. Geological Survey–Montana Cooperative Fishery Research Unit. The project also supports one graduate student, Kiza Gates, who is pursuing a masters degree in the Ecology Department at Montana State University. This study will quantify sediment on angling equipment, determine if the sediment contains myxospores, and record sediment load and presence of myxospores on various wader and boot types. Early work showed that salmonid anglers in Montana pursue this activity very widely—globally, in some cases; therefore, the investigators will formally characterize their movement to determine their potential role in transporting myxospores and other invasive species. The team's research results will feed directly to management strategies aimed at reducing spread of whirling disease

Studying angler movement and the spread of aquatic diseases.

and other invasive species in Montana and beyond. Most significant is the role these data will play in refining a risk assessment model to identify angler transportation corridors for education purposes and wash station placement. Also, these data will help managers determine if adjustments to wader type, equipment care, and equipment transport methods are needed.

The potential of vehicles and fomites to transfer the agent of whirling disease. Paul W. Reno, Oregon State University. To learn more about vectors for the whirling disease parasite, Dr. Reno is studying the likelihood of transferring it from site to site by a mechanism other than movement of fish. Two potentially likely indirect methods of transfer to be examined are passive transfer by birds and movement via contaminated waders. Objectives are to: (1) determine if piscivorous, scavenger, or herbivorous birds can transfer the agent of whirling disease to either piscine or tubificid hosts over a short time interval—thereby emulating scenarios that might occur in a field situation, and (2) determine if angler-associated fomites, specifically waders, can transfer the agent of whirling disease to either piscine or tubificid hosts over a short time interval—emulating inadvertent transfer from watershed to watershed during fishing.

Assessment of the risk of *Myxobolus cerebralis* introduction and establishment. Jerri L. Bartholomew, Oregon State University. This project will use a working risk assessment model to evaluate and compare the risk of *M. cerebralis* introduction and establishment in two different anadromous systems—Alaska and the lower Columbia River Basin in Oregon. These provide two different scenarios to compare disease risk in sys-

Gathering data for risk analysis in the CRB.

tems with anadromous fish. In Alaska, the parasite is not known to occur and introduction routes are suspected to be limited. However, there is little information available on the potential for its establishment, if it were to be introduced. In Oregon, there are numerous potential introduction routes but environmental conditions and absence of susceptible tubificid hosts may limit establishment in some tributaries. Comparison of risks of introduction and establishment in these systems will provide not only a greater understanding of the ecology of whirling disease, but will provide guidelines for resource managers on where efforts to limit spread and establishment would be most effective. Specific project objectives are to: (1) define the parameters of the risk assessment for whirling disease and review the existing data gaps in critical information, (2) conduct a release assessment to evaluate the likelihood of *M. cerebralis* being introduced in the two systems, and (3) conduct an exposure assessment to evaluate the likelihood of *M. cerebralis* becoming established in the two systems.

Analysis of epidemiology data for whirling disease in the Rock Creek, Montana. Willard Granath, University of Montana. The purpose of this project is to analyze the data that have been collected in Rock Creek since 1998, concerning whirling disease and its environmental correlates. These data address:

- disease severity in trout, gleaned from sentinel cage deployment throughout the watershed,
- prevalence of *M. cerebralis* in *T. tubifex* at numerous locations in Rock Creek,
- benthic macroinvertebrate counts throughout Rock Creek,
- habitat status of Rock Creek based on EPA habitat assessment protocols,
- water quality measurements (temperature, pH, dissolved oxygen, total dissolved solids, etc.) at sentinel cage and other locations, and
- water flow measurements (since 2001) at sentinel cage and other sites.

These data require significant analysis and interpretation which should lead to a better understanding of disease transmission in this drainage, and indirectly aid fishery biologists in making management decisions.

The role of sediment size distribution and other microhabitat factors in the abundance and relative dominance of various *T. tubifex* lineages. Dana Winkelman, Terry Waddle, Kevin Thompson, Jim Terrell, and Robert Milhous; Colorado Division of Wildlife and Colorado State Univeristy. Ongoing whirling disease research and monitoring by the Colorado Division of Wildlife in Spring Creek and the William's Fork River indicate that these sites are dominated by several strains of *T. tubifex* that differ in their susceptibility to infection by whirling disease. Researchers will examine the relationship between habitat variables and the distribution and abundance of *T. tubifex* lineages in these systems. Potential differences in habitat requirements for the different strains will be evaluated by comparing strain abundance and dominance (as determined by PCR analysis and paired kicknet/core samples) with particle size distributions and organic content of core samples at each stream site. Researchers will conduct similar evaluations on the Poudre River in 2005 to assess habitat relationships in another system.

Use of high resolution thermal imagery as a tool to locate *Tubifex tubifex* in Pelican Creek, a *Myxobolus cerebralis*-positive stream in Yellowstone National Park. Billie Kerans and Todd Koel; Montana State University and National Park Service. *M. cerebralis* is the cause of a recent, significant decline of spawning, native Yellowstone cutthroat trout in Pelican Creek, a large tributary to Yellowstone Lake. Kerans and Koel will examine the potential of high resolution, thermal imagery and habitat characteristics to detect "hot spots" of *M. cerebralis* infection and high *T. tubifex* abundance. Water temperature plays a critical role in development of the parasite in fish and oligochaetes. In an aerial flyover, NASA mapped the thermal regime of Pelican Creek using a high-resolution thermal imaging sensor. The investigators will validate this thermal imaging as a tool for locating areas of high *M. cerebralis* severity by

linking it with infection risk assessed using infection in tubificids. Specific project objectives are to: (1) document *M. cerebralis* infection risk in Pelican Creek using infection in *T. tubifex* and sentinel fish exposure where possible, (2) assess the habitat characteristics (both physical and chemical) where tubificids are collected, and (3) correlate *M. cerebralis* infection risk to habitat characteristics and high resolution, thermal imagery. Outcomes may include a non-invasive tool to target areas of high *M. cerebralis* infection in stream systems of the Intermountain West.

Researchers sampling at Pelican Creek.

2005-2006 Research Projects

The most recent research projects began in late spring 2005 and will conclude at the end of 2006. A November 2004 announcement yielded 29 pre-proposals, from which the Steering Committee chose ten projects—for a total of $643,000 in federal funding. This round of research will test the effects of environmental manipulations and management method, quantify the risk of disease transmission by various vectors, further develop non-lethal diagnostic techniques, define disease susceptibility of different strains of salmonids, further develop risk assessment schemes, and intensify comprehensive data analysis and synthesis. These projects will be described in next year's report; summaries are available at http://whirlingdisease.montana.edu/resources/research/research.htm.

Creation of a Data Compendium

The National Partnership is teaming with MSU's Big Sky Institute and the U.S. Geological Survey in a special project—building and managing a comprehensive research database of metadata, data, and reports generated from all Initiative-funded research. This entails requesting, collecting, and organizing data from more than 100 very diverse projects reaching back to 1997. When complete, this database will be a clearinghouse/repository of cutting-edge information on the science of whirling disease. It has been designed to contribute to future management solutions by prompting new research that synthesizes findings from completed projects. The infrastructure to make data collection smooth and secure has been created, and past investigators have been queried for their datasets. A data-collection-and-use policy is in development, to protect the rights of the original investigators and the integrity of the data. Initially, all data will be stored electronically in-house and will be accessible only to project personnel. Ultimately, it is envisioned that the database will be web-enabled and will provide an extensive information resource for a diverse audience of researchers, students, and fisheries professionals.

Outreach Activities

In 2004, the Whirling Disease Initiative established an intensive outreach program to provide fishery managers, researchers, land managers and angler groups with whirling disease research information that can be applied, ultimately, in the field. The Water Center hired Amy Rose, who began by developing a contacts list of local, regional and national fishery professionals. She then created a user-friendly national web repository for information on whirling disease research, contacts, maps, graphics, application/outreach tools, conferences, and National Partnership meetings (http://whirlingdisease.montana.edu). Other first-year accomplishments include a quarterly *Whirling Disease Initiative Newsletter* and expansion of a whirling disease research bibliography. Future plans involve collecting whirling disease information and data from disparate sources, keeping the new national whirling disease web site current and information-rich, and assuring that the research database/bibliography is current and searchable. Amy will be spending a great deal of time on the road, sharing this information at meetings of fisheries professionals and angling groups to talk about research findings, risk assessment tools, and state-by-state status-and-trend information.

WILD FISH HABITAT INITIATIVE

Habitat degradation can exacerbate wild fish population loss to predators, exotic competitors, and diseases such as whirling disease, and it is a principal reason for the listing of wild fish as "threatened" or "endangered" under the Federal Endangered Species Act. The purpose of the Wild Fish Habitat Initiative, established in 2002, is to advance the science of restoring stream habitat to support fisheries. The Initiative is a cooperative program of the U.S. Fish and Wildlife Service (Partners for Fish and Wildlife Program), the Montana Water Center, and the Montana Cooperative Fisheries Research Unit. It follows two approaches: research on habitat and population-enhancement techniques, and technology transfer—documentation of past restoration projects for working fishery biologists. The focus is on the coldwater fisheries of the northern Rockies and northwestern U.S.

"Wild Fish" are native or introduced exotic species that reproduce and are self-sustaining in the wild. The Wild Fish Habitat Initiative gives special consideration to habitat restoration projects targeted for native fish populations.

"Restoration" means to "bring back to its original state." In the 21st Century, such a goal is likely impossible due to dramatic changes in land use and character. Therefore, there has been a recent move to reserve the term for true ecological restoration projects; projects that do not address ecological restoration would properly be termed *remediation* or *fish habitat enhancement*. Until consensus is reached and specific standards for ecological restoration criteria are adopted, Initiative personnel have chosen to use the term *restoration* in reference to any river or stream project aimed to improve fish habitat.

Ongoing Research Projects

Effects of coalbed methane development on Great Plains fish assemblages. Alexander V. Zale, Windy N. Davis, and Robert Bramblett, Montana State University. Researchers have embarked on a study to determine impacts of coalbed methane (CBM) development on fish. Disposed coalbed groundwater often contains high concentrations of dissolved ions, elevated sodium adsorption ratios, and sometimes high electrical conductivity. In addition, CBM development requires road and pipeline construction, leading to effects on aquatic environments and fauna. Little research has been conducted on the effects of CBM development on fish assemblages, and no research has compared effects of different CBM product-water management strategies (e.g., direct discharge, treatment, disposal in evaporation ponds, re-injection). The MSU team is studying the influence of CBM development on Montana and Wyoming habitats and on intermittent prairie stream fish assemblages. Sampling with seines, the objective of the study will be to: (1) compare fish assemblages in streams with CBM development to those in similar streams without development, (2) compare fish assemblages in reaches upstream of development to those downstream of development within the same stream, (3) compare areas of pre- and post-CBM development in the same stream, and (4) capture fish present in areas without development, and place them in cages in developed areas absent of fish to test for acute toxicity.

Entrainment losses of westslope cutthroat trout to irrigation diversions, the effectiveness of fish screens at precluding entrainment, and the recruitment contribution of Skalkaho Creek westslope cutthroat trout to the Bitterroot River, Montana. Alexander V. Zale, Christopher Clancy, Steve Gale, and Ryan Harnish; Montana Cooperative Fishery Research Unit, Montana Fish, Wildlife and Parks, and Montana State University. The Bitterroot River supports both non-migratory resident and fluvial migratory westslope cutthroat trout *Oncorhynchus clarki lewisi*. However, habitat fragmentation, dewatering and migration barriers have led to the decline of the migratory form. Despite its healthy population of westslope cutthroat trout, Skalkaho Creek tributary contributes little flow and few migratory cutthroat trout to the Bitterroot River. This study examined seven lowhead dams on lower Skalkaho Creek that divert downstream migrant westslope cutthroat trout into irrigation canals. Post-spawn adults migrating back to the Bitterroot River and juveniles emigrating downstream from nursery reaches

of Skalkaho Creek can become entrained, and die in the irrigation canal system. In 2003 the team estimated fish losses prior to installation of the screens. They noted significant entrainment, particularly of age-0 juveniles, at the unscreened diversions. After installation, entrainment of both age-0 juveniles and adults was high at unscreened diversions but negligible or absent at screened diversions. However, emigration of juveniles to the Bitterroot River did not appear to be enhanced by the screens as much as anticipated, apparently because the migratory life history component in Skalkaho Creek has been selected against for over a century. To help managers, the team has developed an ongoing survey to collect barrier design data and information on structural and passage failure. Survey results can be viewed at http://wildfish.montana.edu/projects/barrier/browse.asp.

Looking downstream at a fish screen.

Evaluation of the efficiency and efficacy of piscicides for use in non-native fish eradication. Alexander V. Zale and Peter J. Brown, Montana State University. Native fish conservation is a strong focus for resource managers, often because of threats posed by non-native fish species. Fishery restoration projects initiated to conserve threatened species typically employ fish toxicants (piscicides) to eradicate non-native fish species. Despite the widespread use of piscicides, there is little standardization of application techniques, and their efficacy can be affected by pH, UV radiation, and stream gradient. Therefore, the objective of this project is to increase the success rate of native fish restoration projects through improved non-native fish eradication techniques. Zale and Brown are investigating conditions that degrade the toxicity of piscicides. Laboratory experiments at the Wild Trout Research Laboratory are exposing piscicide-treated water to each of three environmental characteristics (turbulence, ultraviolet light, and organic matter) and measuring the toxicity of the piscicide-treated water directly by fish bioassay. The next step will be to treat restoration field sites with a single application of piscicide and measure the duration of toxicity using sentinel fish. The team will then develop models to predict piscicide toxicity. By measuring the physical characteristics of potential restoration sites and applying models that predict piscicide toxicity, they will predict the probability of complete non-native fish eradication in streams. These probabilities will be tested during the subsequent eradication projects to determine the validity of the models. Future activities include experimental tests of eradication and exclusion techniques. Guidelines for the use of piscicides in varying water chemistries and conditions will be developed, providing managers with guidance for increased success in native fish conservation.

Evaluation of habitat restoration for the conservation of cutthroat trout. Alexander V. Zale, Brad Shepard and Mark Taper; Montana Cooperative Fishery Research Unit and Montana State University. The distribution and abundance of westslope and Yellowstone cutthroat trout *(Oncorhynchus clarkii lewisi* and *bouveir)*, subspecies native to the Northern Rocky Mountain region, have shrunk from historical levels. Both subspecies are considered at risk for listing under the Endangered Species Act. Few studies have quantitatively assessed the response of cutthroat trout populations to habitat restoration, and the threat of predation by non-native brook trout. The study will describe what constitutes high-quality habitat for westslope and Yellowstone cutthroat trout in central Montana, and it will determine how habitat condition and the

Collecting fish population data.

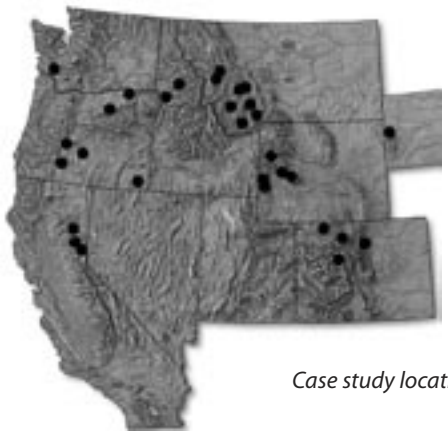
presence of brook trout interact to reduce densities of cutthroat trout. The second phase will evaluate the success of habitat restoration projects that targeted cutthroat conservation. To date, the team has compiled a 4,500-site database of species presence data for brook and cutthroat trout throughout the range of cutthroat trout in Montana and Idaho. Another database consists of systematic samples within seven major basins in Montana of fish abundance information, fish population estimates and habitat survey data. Information from these two databases is geo-referenced within a geographic information system to be correlated with many of the physical attributes tested.

Project Concluding In 2005

Thermal requirements of westslope cutthroat trout. Tom McMahon, Alexander Zale, Beth Bear, and Bill Krise; Montana State University and Bozeman Fish Technology Center, U.S. Fish and Wildlife Service. Westslope cutthroat trout *Oncorhynchus clarkii lewisi* have declined throughout their native range in the Northern Rockies. Water temperature is widely regarded as essential to their persistence, but specific lethal levels and thermal optima for this subspecies had not been defined. This laboratory study used the acclimated chronic exposure method to determine tolerances and thermal optima of westslope cutthroat trout and rainbow trout *Oncorhynchus mykiss*, a potential non-native competitor. Rainbow trout had a distinct survival advantage over westslope cutthroat trout at warmer temperatures. The ultimate upper incipient lethal temperature—the temperature at which 50 percent of the population survives for 60 days—for rainbow trout was 4.7°C higher than that of westslope cutthroat trout. In contrast, the optimum growth temperature for westslope cutthroat trout over the 60-day test period was very similar to that of rainbow trout, although rainbow trout grew better over a wider range and at higher temperatures than did westslope cutthroat trout. The upper lethal and optimum growth temperatures for westslope cutthroat trout are in the lower range of most salmonids. The higher upper temperature tolerance of rainbow trout and its greater ability for growth at warmer temperatures may account for its increased occurrence at lower elevations than cutthroat trout. To ensure suitable thermal habitat to maintain the persistence of westslope cutthroat trout populations, water quality standards should be set at maximum daily temperatures ranging from 13 to 15°C—near the optimum growth temperature of the cutthroat. In addition, survival and growth parameters indicated in this study can be used with stream temperature modeling to predict suitable habitat for westslope cutthroat trout, as they may be particularly susceptible to increases in stream temperature associated with climate change. Such predictions of habitat suitability will be vital in prioritizing conservation efforts with respect to reintroduction and translocation of westslope cutthroat trout.

Case Histories Database

Although scores of fish habitat enhancements have been implemented, very few have been shared in professional literature. An ongoing Initiative project is to collate information on methods and results of fish habitat restoration projects within the Intermountain West. Information collected for each case history includes narrative descriptions, project goals, restoration methods, project costs, landowner contributions, photographs and monitoring data. It is organized in a database, accessible at the Initiative web site: http//:wildfish.montana.edu/.



Case study locations.

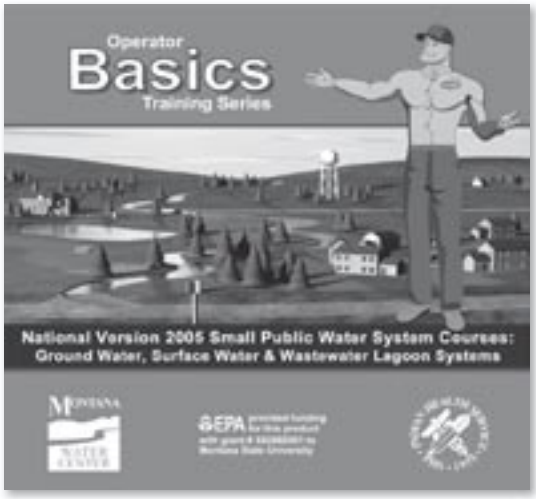
Along with the case studies, the site now includes summaries and progress reports of all Initiative research projects, a searchable bibliography related to fish habitat, a selection of downloadable habitat restoration manuals, and links to pertinent online habitat restoration information. The online bibliography is a collation of information on various fish habitat restoration techniques chosen to facilitate information exchange among fisheries biologists and project managers. Presently, there are more than 1,000 literature entries available in the bibliography. In addition, fifteen habitat restoration manuals are showcased on the web site. These were selected to provide information relevant to the western region. The manuals are available in downloadable-PDF format.

Small Drinking Water Systems Technical Assistance

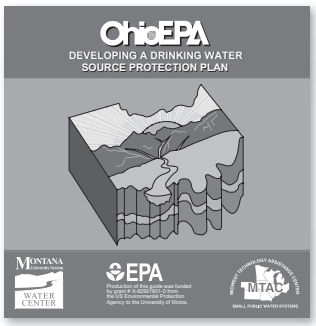
Funded by the U.S. Environmental Protection Agency, eight regional Small System Technical Assistance Centers work to protect public health, improve water system sustainability, and assure regulatory compliance by small public water systems. The Montana Water Center operates one of these centers, and takes a lead in developing training tools for water system operators nationwide. Training tools developed by our Center may be used, downloaded or ordered (most are free of charge) from our training site: http://water.montana.edu/training/. Project descriptions and resources from all eight Technical Assistance Centers can be accessed on the TACnet web site maintained by the Montana Water Center: http://www.tacnet.info.

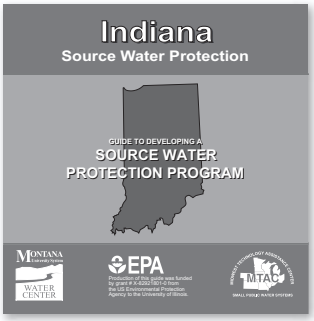
TRAINING TOOLS

This year, the Montana Water Center Media Team announced the availability of the long-awaited comprehensive computer-based training for operators of small water and wastewater systems. *Operator Basics 2005* contains over 20 hours of curriculum in three courses—*Surface Water Systems, Ground Water Systems, and Wastewater Lagoons*—and a "Water Exploration" showcase, all designed to prepare small system operators for certification. The revised software also offers a math practice section with 500 animated math problems and solutions, 500 exam preparation quiz questions, study games, a glossary and links to useful resources. Access to print and copy content is free. Operators nationwide consult a support site at http://water.montana.edu/training/ob2005/ to see if their state certification agency has approved this training for credit. The National Environmental Services Center distributes *OB2005* through its web site at http://www.nesc.wvu.edu/ndwc/ or by phone at (800) 624-8301.



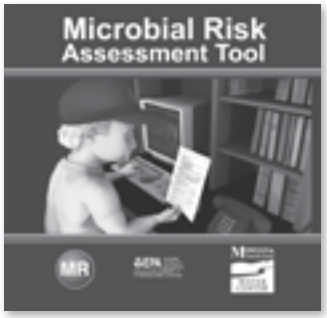
As it has done for the states of Illinois, Montana, and Pennsylvania, the media team this year developed *Source Water Protection Training Interactive Guides* for Indiana and Ohio. Using a template-based approach, these guides are useful for operator training and for producing source water protection plans. The courses vary in duration and complexity. All provide multimedia training on basic concepts and detailed guidance on source water protection planning. The Ohio version incorporates surface water protection training along with ground water concepts. The Indiana training tool was created to simplify the process of developing a source water protection program for small public drinking water systems in the state. Both guides are available in CD-ROM, web, download, and printable versions free of charge.





Work is in progress on the *Virtual System Explorer*, an immersive "Exploration" of three small public drinking water systems in DVD format using full-screen video and animation. Users begin with a narrated, two-hour overview of system operations. They then progress to a half-hour interactive tour of each system—a ground water system with no treatment, a ground water system with treatment and a small surface water treatment system. Each tour is followed by detailed simulations of common operational problems, which the user must diagnose and "fix." The audience for the Explorer will be small-water-system operators and managers, and regulatory personnel. This tool can be used for continuing education, workshops, and at-home viewing on a standard DVD player.

ASSESSMENT TOOL



Microbial contamination is a continuing threat to small water systems. The *Microbial Risk Assessment Tool* is a new computational tool that helps small water system managers and operators assess their systems' vulnerability to microbial contamination. The tool is applicable to water systems that draw their water from any combination of sources including springs, wells, and surface waters. Users complete a survey and enter their answers into an Excel spreadsheet that ranks contamination risks in order of urgency. If necessary, it suggests remedial action. The ranking tool spreadsheet was developed by Dr. Phil Butterfield, University of Washington. The Water Center's media team created an Excel "Getting Started" tutorial and additional guidance to help users complete the survey accurately and efficiently. This tool is distributed free of charge by the National Environmental Services Center.

RESEARCH

Kate Miller

Each year the Small System Technical Assistance Center program solicits practical solutions through research. This year Montana Bureau of Mines and Geology geohydrologist Kate Miller is working to identify the best indicators of fecal contamination in ground water. Preliminary data suggest that current indicators of fecal contamination (total coliform, heterotrophic plate count, nutrients) in ground water may be less sensitive than coliphage assays. Miller initiated her project, **Demonstration of somatic and F+ coliphage, E.Coli and enterococci as indicators of fecal contamination in small public water supplies in southwestern Montana**, to demonstrate the effectiveness of these indicators. She is targeting hydrogeologically-sensitive aquifers used by small public water systems in southwestern Montana, although results will be transferable to areas with similar geochemistry, hydrogeology and land use. The findings will help Montana's regulatory agencies select the most sensitive and cost-effective fecal indicators for public water systems using ground water. They may also save money for the public water systems.

A study by Phil Butterfield, **Assessing the Long-term Microbial Safety of Ultraviolet Light Disinfection Point-of-Use/Entry Treatment Devices**, addressed the question of whether bacteria and viruses are effectively inactivated by typical point-of-entry ultraviolet (UV) light disinfection treatment such that these organisms will not persist within the biofilm of a residential plumbing system. The primary objective was to assess the ability of select microorganisms to survive and possibly repair their DNA after UV treatment with special emphasis on the role of biofilm as an environment for survival. The research was designed to provide practical information on this important question. Results showed that care should be taken in the application of point-of-use UV disinfection units as a single barrier for protection from bacterial and viral pathogens. A major consideration should be the potential for fecal contamination of the source water. In the case of a relatively good quality ground water there is less likelihood for high virus or bacterial pathogen concentrations and therefore the inactivation levels should be sufficient. When virus concentrations could exceed 10^4 per L then there is a greater chance that viable viral particles will survive initial disinfection. Long-term survival in the pipe system does not appear to be an issue for the virus tested, but that possibility cannot be ruled out based on research showing persistence of other viruses in drinking water system biofilm.

U.S. Geological Survey Water Research Program

Each year, Montana investigators and graduate students study complex water quantity and quality problems, with seed funding from the Water Center provided by the U.S. Geological Survey's Water Resources Research program. This program is guided by our Water Resources Research Advisory Committee. This year the committee not only set the topical priorities for the seed grant program, but directed that substantial funding be allocated to the Water Center's pilot Student Research Fellowship program. The fellowship program allows undergraduate or graduate students at Montana institutions engaged in water research to apply for research support stipends ranging from $1,000 to $5,000. This year the program named 12 student research fellows.

RESEARCH PROJECTS

Projects Completed In 2004

Pharmaceuticals in septic system effluent. William Woessner and Emily Godfrey, University of Montana. How pharmaceuticals enter the environment and, ultimately, ground water supplies, was studied by a University of Montana research team. They examined occurrence and concentrations of selected pharmaceuticals in waste-water treatment and septic systems. Thirty-two single-family and ten multiple-family septic tanks, and the influent and effluent wastewater from the community wastewater treatment plant in Missoula, Montana, were sampled and tested for 19 drug residues and three drug metabolites of both prescription and non-prescription drugs. Eighteen of the 22 pharmaceuticals were present in the septic tanks, 12 were detected in the WWTP influent, and nine were detected in the WWTP effluent. The most frequently detected (greater than 50 percent) non-prescription drugs were, acetaminophen, caffeine, and nicotine, as well as metabolites of caffeine (paraxanthine) and nicotine (cotinine). Prescription drugs were detected less than 30 percent of the time, with the exception of warfarin, which was detected in approximately 77 percent of the samples. Prescription drugs found most frequently were codeine, trimethoprim and carbamazepine. This work suggests that concentrations of pharmaceuticals, originating from both septic effluent and wastewater treatment plant effluent could be leaving these treatment systems and entering the associated surface water or ground water resources in Missoula. Study is needed on their chemical, physical, and biological fate.

Sampling drain field effluent.

Recharge assessment of the Anaconda Mine near Belt, Montana. Jon Reiten, Montana Bureau of Mines and Geology. For decades, acid mine drainage from underground coal mining has contaminated ground-water and surface-water resources in Belt, Montana. As a result, the pH of Belt Creek has decreased and trace metals have increased in the stream. This research team set out to define the hydrogeologic regime in the vicinity of Belt so

that recharge associated with old mine workings and the source of acid mine drainage could be delineated with certainty. Initial interpretations show the roughly 260-foot Kootenai Formation as a significant source of water to the Anaconda Coal Mine in the Belt area. A potentiometric surface map of the Kootenai Formation was constructed using well inventory and monitoring measurements from 44 wells and springs near the mine. Ground water appears to flow from a divide located 3.5 miles south of the mine. The potential recharge area covers about 2,100 acres overlying, and up gradient of the mine. Data indicates that recharge to the mine is likely locally derived. As a result, acid drainage may be reduced or possibly eliminated by changing land use in the recharge area. Growing alfalfa or other water-consumptive crops under a strict irrigation water management regime could have the potential to reduce infiltration and possibly decrease the acid mine drainage to Belt Creek.

Drainage from the Anaconda Mine.

Understanding and predicting changes in the microbial ecology of mine tailings in response to the addition of dissolved organic carbon. Paul Sturman, Montana State University. Sturman's team explored how tailings treated with a carbon source immobilize heavy metals often found in untreated abandoned mines. They began their work with two questions: Can microbial populations within acid-producing mine tailings be influenced by the addition of dissolved organic carbon? Furthermore, can heterotrophic bacteria, when stimulated with a carbon source, consume dissolved oxygen from infiltrating water, and thus promote the activity of anaerobic sulfate-reducing bacteria through the tailing pile? The research team from the Biofilm Engineering Center used cheese whey and molasses as a carbon source. They collected toxic mine tailings from four mining sites in Montana and Canada to study not only how the bacterial activity that oxidizes iron facilitates the generation of acids, but also how sulfate-reducing bacteria can reverse the process. The answer lies in the application of the carbon sources. The results illustrate both the promise of using organic carbon to abate acid mine drainage through stimulation of sulfate-reducing bacteria, and the potential to inhibit remedial efforts through the inadvertent stimulation of iron oxidizing bacteria. Although increases in bacterial populations were not well correlated with the concentration of organic carbon, it is apparent that even relatively low levels of whey and molasses addition can stimulate activity of sulfate-reducing bacteria over 1000-fold. USGS seed funding for this project has attracted substantial additional federal funding.

Dr. Sturman and laboratory columns of tailings.

***Potamopyrgus antipodarum and Baetid* mayflies: temporal variation and community-level consequences. Billie Kerans, Montana State University.** Introduction of New Zealand mud snails in the United States is causing significant direct and indirect problems. Montana State University researcher Billie Kerans studied the consequences of introducing mud snails to a popular Montana trout spring creek fishery to determine effects on macroinvertebrate and periphyton assemblages. Her team also wanted to determine effects of potential mayfly losses on several fish species. To do this, they examined mud snail and mayfly

densities and biomasses, as well as periphyton biomass and fish diet and growth, in reaches containing high and low mud snail densities. The presence of mud snails exerted a negative effect on periphyton biomass, the hypothesized resource for which mud snails and mayflies compete. However, densities of mayflies did not respond as strongly to high densities of mud snails as expected. In competition experiments, baetid mayflies negatively affected mud snail survivorship but not growth. Similarly, *Potamopyrgus* negatively affected the survivorship but not the growth of the mayflies.

Electroshocking.

Topography, ground-water dynamics, and soil frost: first-order controls on snowmelt runoff dynamics and plant species distributions across an upland-wetland transition. Brian McGlynn, Montana State Univeristy. Montana's Red Rocks Valley is the location of this study examining the controls on snowmelt flow pathways, frost depth, and plant species distributions across an upland–wetland transition. It is a first step in the development of a conceptual model of snowmelt flowpaths and hydro-ecologic dynamics at the landscape scale. The hydrologic dynamics and plant species distributions appear tightly linked at Red Rock Lakes in the Centennial Valley, making this an ideal site for new investigation in the emerging field of hydroecology. Results indicate that significant ground water recharge occurs at the mountain front, ground water-surface water exchange is dynamic (spatially and temporally), and ground water recharge and ground water-surface water exchange control valley bottom aquifer storage, surface water chemistry, and stream discharge magnitude.

Assessing snowmelt runoff dynamics.

Ongoing Projects

Amphibian habitat distribution and population structure of Columbian spotted frogs, *Rana luteivintris*, in western Montana watersheds. Lisa Eby, University of Montana. The famous busyness of beavers benefits species other than themselves, according to a University of Montana ecologist. They create wetland habitats conducive to breeding-amphibian populations. It is estimated that 60 percent of Montana's threatened or endangered species rely on wetlands for habitat and food. In Montana, one third of amphibian species are listed as species of concern; many of these utilize wetland habitat for breeding. Dr. Lisa Eby was awarded a grant to study how amphibians in Montana are influenced by beaver activity. Habitat fragmentation and destruction is one of the leading causes of amphibian population declines. However, beavers may reverse this trend. Dr. Eby is examining differences in amphibian populations among watersheds with and without beavers, using aerial photographs from the past 70 years. She hopes to find how the amphibian population functions as the landscape changes. Preliminary findings show the watersheds with the most breeding activity currently have beaver activity or have had beaver activity. As conservation efforts are typically reactive rather than proactive, Dr. Eby hopes her findings will enable land managers to manage their lands proactively. For instance, managers could work to increase beaver populations or construct man-made wetlands to increase amphibian populations before more species become threatened. Benefits from beaver activity to the watershed extend beyond increasing breeding activity of amphibian populations. Future research could examine the extent to which the presence of beaver ponds

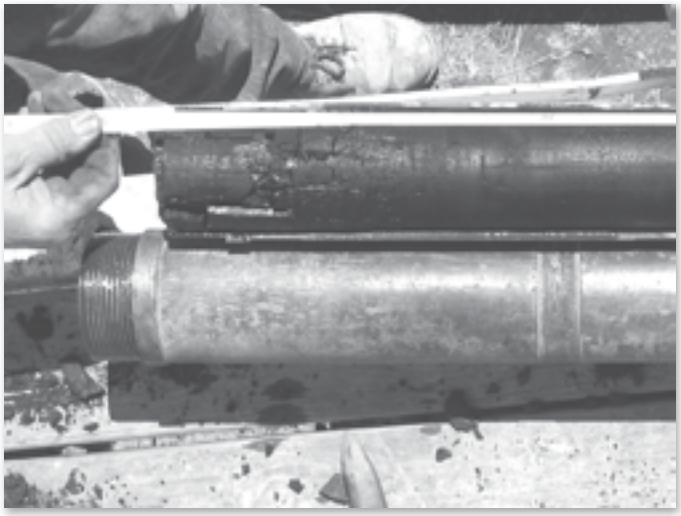
prevents dewatering of streams during dry periods. These ponds are storage areas that release water slowly providing important base flow. Additionally, beaver ponds could be used as settling ponds in areas that have high sediment runoff due to grazing.

Recording wetland samples.

Evaluation of various methods to assess condition of perennial stream ecosystems. Clayton Marlow, Montana State University. Many land management agencies infer the condition of water quality and fish habitat from land-based evaluations of riparian vegetation and channel morphology. Even so, there has been minimal documentation that metrics used in riparian condition inventories are correlated with water quality or instream habitat conditions. Clayton Marlow studied this hypothesis in eastern Montana. Only one of the evaluation protocols studied shows different results for eastern and western stream reaches in the state of Montana. All other protocols could not significantly distinguish between western and eastern provinces. The implications of this are that each application has its own bias and robustness, and that the integration of certain methodologies would lower assessment costs and provide a better understanding of aquatic and terrestrial condition.

Investigation of microbial ecology, structure and function in coalbed aquifers: Powder River Basin, Montana. John Wheaton, Montana Bureau of Mines and Geology. Coalbed aquifers are not only sources for water supplies and potential coalbed methane (CBM) development; they can serve as repositories for industrial CO_2. Since microbial processes (biological methanogenesis) produce CBM, and the success of CO_2 sequestration strategies will likely be a function of microbial activities, Wheaton's team set out to identify the structure, diversity and function of the microbial community within a methane-bearing coalbed. They conducted culture-based investigations to help delineate the kinetic rates and pathways for methanogenesis. Their goal is to generate data to support more advanced studies of *in situ* gasification of coal as it relates to methanogenesis, CO_2 sequestration, and the development of technologies appropriate for sustainable methane development. The investigators foresee the value of these data as supporting a move toward harvesting CBM rather than simply mining this resource at the expense of ground-water resources. They plan to follow this project with extended studies and modeling of the microbial community within coal samples, along with design of primers for molecular analysis of microbial populations responsible for methane production.

Sampling macro-invertebrates on Nevada Creek near Helmville.



Coal core.

Defining river recharge and three-dimensional areas of contribution to production wells adjacent to a losing river. William Woessner, University of Montana. The Clark Fork River in Missoula, Montana provides 50 to 80 percent of the recharge to the Sole Source Missoula Aquifer that serves over 60,000 Missoula area residents. If this recharge source to the unconfined aquifer becomes contaminated, water for municipal and private wells may be at risk. The purpose of this work is to define the zones of contribution and source water quality. Field activities included characterization of stream stage, streambed temperature gradients, streambed vertical gradients, streambed hydraulic conductivity, water level trends, the distribution of aquifer hydraulic conductivity, and both vertical and horizontal gradients. These parameters were used to develop and calibrate a three-dimensional transient ground water flow model that examines the timing, quantities and sources of water to riverside production wells. The preliminary conceptual model suggests the river is perched 5 to 16 feet above the aquifer and is losing water to the aquifer. The wells derive about 90 percent of their water from river recharge and approximately 7 percent from underflow originating from an up-gradient canyon. Numerical modeling will evaluate the current conceptual model and test additional representations as new data are generated.

Defining recharge by the Clark Fork River, Missoula.

Quantitiative assessment of the effectveness of post-fire erosion control techniques. Scott Woods and Tom DeLuca, University of Montana. Soil erosion rates in undisturbed forested watersheds are typically very low. It's not surprising that erosion increases substantially after forest fires due to the loss of the protective duff layer. Increased erosion causes other problems like loss of soil productivity and increased sedimentation in streams. Costs of implementing post-fire erosion control projects are extremely high, so it is essential that selected treatments are effective. This study evaluated the effectiveness of two commonly used hillslope post-fire erosion control treatments—aerial seeding and straw mulching. The results indicate that seeding and mulch both reduce total runoff, peak runoff and erosion from burned areas. However, mulching is more than three times more effective in reducing erosion than seeding. Mulching may therefore be a more desirable treatment than seeding in situations where both treatments are being considered. Research will continue to determine the longer-term effectiveness of these treatments, and their effect on natural revegetation rates.

Rainfall simulator used for post-fire erosion control study.

2005-2006 Projects

In January 2005, the Water Center made awards to two research teams. Dr. Brian McGlynn, and doctoral candidate Kristin Gardner, Montana State University, will conduct **Geographic analysis of land use/land cover change and its relation to nitrogen export in a developing mountain landscape**. Researcher Denine Schmitz and Dr. Duncan Patten, Montana State University, received an award for a project titled, **Using paleoecology and paleoflood hydrology to assess the long-term ecological response of Montana's riparian and aquatic ecosystems to small natural and human dam failures – a pilot study**.

STUDENT RESEARCH FELLOWS

In summer 2004 the Water Center's first Student Fellow, University of Montana graduate student Megan McBride, conducted research entitled *Recreation on the Upper Yellowstone River: use and place attachment*. The 2005-2006 awards were offered through a competitive process to one undergraduate, six masters, and five doctoral students. Alphabetically, they are:

- Brian Bellgraph, Montana State University, *Movement, habitat use, and food habits of sauger and walleye: an investigation of resource overlap in the middle Missouri River, Montana*.
- Jennifer Corbin, University of Montana, *The effects of glacial meltwater chemistry, microbial processes and climate change on nitrate loading and ecological response in high alpine aquatic systems*.
- Timothy Covino, Montana State University, *Mountain front ground water recharge: groundwater /surface-water exchange across an alpine/valley transition*.
- Kiza Gates, Montana State University, *Movements of resident and non-resident anglers in Montana: implications for transferring whirling disease among drainages.*
- Motoshi Honda, University of Montana, *Relationships between flood frequency and riparian vegetation distribution in montane streams of western Montana.*
- Levia Jones, Montana State University, *Temporal effects of wildfire on riparian ecosystem function.*
- Lewis Kogan, University of Montana, *Antibiotic resistance in ground- and surface-water microbes in the Missoula area.*
- Vince Pacific, Montana State University, *Watershed carbon distribution and flux across environmental gradients.*
- Mary Louise Polzin, University of Montana, *Clonal recruitment of* Populus angustifolia *along the Yellowstone River: extent and requirements.*
- Mohammed Rahman, Montana State University, *Towards sustainable materials for drinking water infrastructure.*
- Diego Riveros, Montana State University, *Importance of hydrologic controls on CO_2 efflux variability at the catchment scale.*
- Brad Shepard, Montana State University, *Factors that influence displacement of native cutthroat trout by nonnative brook trout.*

Water Center's First Fellow Shares Research Results: Recreational Impacts in the Yellowstone Watershed

Last year, the Montana Water Center initiated a student water research fellowship program by making its first award to University of Montana's Megan McBride. This year, she completed her study, *Recreation on the Upper Yellowstone River: a study of use and place.*

The Yellowstone River remains one of the most beloved recreational spots in North America. McBride attempted to characterize the recreational qualities of the Yellowstone River by seeking an understanding of recreationists' attachment to place, concepts of a special recreation area, and learning more about recreationists using the upper Yellowstone River. She used a quantitative survey, which was completed by 307 individuals. The survey looked at each individual's recreation activities, satisfaction levels, attachment to place and level of concern regarding growth along the upper Yellowstone River. Her analysis consisted of reporting means and frequencies of activities, satisfaction levels and demographics.

Results show that recreationists participate in a variety of activities along the upper Yellowstone, and are generally "very satisfied" with their recreation experience. Place attachment depends on two factors: place identity and place dependence. The place identity dimension was stronger than place dependence among recreationists, indicating a strong emotional attachment to the river. Megan's study revealed not only the multi-dimensional nature of what makes a place special, but also the concern among recreationists in terms of development. In effect, individuals' emotional connections to the watershed are changing because of increasing development along the banks of the upper Yellowstone River. She concludes that development and its effects on recreationists' attachment to place should be further studied.

Water Information and Services

This year the Montana Water Center expanded several outreach programs and tools to carry out its mission to publicize water research and share outcomes with future professionals.

ELECTRONIC OUTREACH

Besides a new design and improved navigation for the Center's web site (http://watercenter.montana.edu), we also created new features for *Montana Water*, the electronic hub of all things water in Montana. This web site of the Water Center and partner agencies is maintained daily to present an events listing, news updates, an online library, water-resource forums, a Montana watersheds projects database, an expertise directory, water facts and more. To further assist researchers, educators, agency personnel and watershed groups, we continued to issue the monthly electronic *Montana Water News*. This e-publication has a circulation list of more than 1,300. You can view *Montana Water* and archives of the *Montana Water News* e-newsletter at http://water.montana.edu.

AUDIO OUTREACH

We welcome the opportunity to share the knowledge of visting experts and were able this year to facilitate a lunch lecture and help organize a National Public Radio presentation. April E. Huffman, visiting scientist from the Office of RECVOER, South Florida Water Management District, presented *"The Everglades: Complexity and Challenges of Implementing and Assessing Landscape Scale Restoration"* to Montana State University faculty. For a regional National Public Radio discussion on Aquatic Nuisance Species (ANS), we invited Billie Kerans, MSU research ecologist; Tina Proctor, U.S. Fish and Wildlife Service ANS program Director; and Eileen Ryce ANS specialist from Montana Fish, Wildlife and Parks, for a one-hour "Science and Policy" discussion hosted by NPR Billings News Director, Jacquie Yaminaka, which aired last August.

TECHNICAL ASSISTANCE

This year our team of web designers assisted the Montana Watercourse Water Monitoring Project, the National Institutes for Water Resources, the Universities Council on Water Resources, the Montana Cooperative Fisheries Research Unit and the Whirling Disease Initiative with web design and data management templates. As an example, the water-monitoring project allows teachers and students who are conducting stream sampling and water analysis to enter and compare water-monitoring data over time and among river basins. The template will allow classes from different schools to compare and analyze data online.

CONFERENCES

NIWR Annual Meeting. With Montana Water Center Director Gretchen Rupp serving as President-Elect of the National Institutes for Water Resources, our Center organized and hosted the 2005 annual meeting of the Directors and staff from the 54 water resources research institutes. The meeting was conducted in Washington, D.C. on March 5-8, 2005. Planning activities included development of the meeting web site, development of program and registration materials, and communications with all 54 directors. At the meeting, the Directors deliberated on a strategic plan for the organization and on future collaborative efforts. More information about the 2005 Annual NIWR Meeting is found at http://water.montana.edu/niwr/.

Senator Burns addressing the meeting of the water Institutes.

Annual Montana Water Conference. A record 170 water scientists, managers and students attended the 21st meeting co-sponsored by the Water Center and the American Water Resources Association's Montana Section. This took place in Helena on October 4-5, 2004. The morning field trip, guided by USGS and Forest Service scientists, visited post-fire erosion sites in the Canyon Ferry area. Later, keynote speaker Jane Jelinski, Director of the Local Government Center at MSU, kicked off the presentation of 37 professional papers and posters addressing *Montana's Water Outlook: Current and Future Challenges*. Jelinski spoke about "Challenges faced by local decision-makers making land-use and water-use findings."

2004 water conference field trip to Canyon Ferry.

A number of students participated in the meeting, and these student awards were made:

First prize paper: Kristin Gardner, Montana State University
Second prize paper: Ryan McLane, Montana State University
Third prize paper: Steve Parker, Montana Tech
First prize poster: Tim Covino, Montana State University
Second prize poster: Kristin Gardner, Montana State University

You can download meeting proceedings at the Montana AWRA web site (http://www.awra.org/state/montana/).

American Water Works Association Teleconferences. This year two four-hour teleconferences were offered for water professionals: *Emerging Issues in Water Utility Operations*, and *Water Resource Alternatives: The Future of Sustainable Utility Practices*. Montana downlinks were organized by the Montana Water Center; about 40 water-system professionals attended at downlink sites in Missoula, Havre, Great Falls, Billings, Helena, Butte and Bozeman.

71st Annual Water School. The Montana Water Center co-sponsored the Fall Water School on September 27-30, 2004 at Montana State University. This school is designed for entry-level and experienced water and wastewater systems operators and managers. About 180 operators and 15 vendors took part in classes on electrical safety, technology in distribution, filter assessments, public health, pumps, telemetry, disinfection, and lagoon operations. Final exams offered by Montana Department of Environmental Quality Certification Office were taken by 81 operators.

Whirling Disease Symposium. In keeping with a longstanding tradition of collaboration with the Whirling Disease Foundation, the Montana Water Center co-sponsored the 11th Annual Whirling Disease Symposium, *Recipes for Recovery*. Held in Denver February 3-4, 2005, this national meeting focused particular attention on building management solutions and a risk assessment model for evaluating the disease. The Water Center provided funding, planning assistance and moderators for the symposium.

PUBLICATIONS

International Drinking Water Colloquium Proceedings. In May 2004, the Montana Water Center organized an International Drinking Water Colloquium of water experts in Bozeman, Montana. Forty-six invited experts from 15 nations discussed drinking-water microbiology, system operation, management, and regulation. This year we published the proceedings of the colloquium; they can be downloaded from http://water.montana.edu/colloquium/.

Our New Water Calendar. We took pleasure in creating the first annual black-and-white, water-facts-and-photos calendar for general circulation entitled *Montana Water 2005*. Each month was dedicated to a different Montana water topic.

Lending Library. The Water Center maintains a lending library of documents and publications relevant to Montana and national water issues. These are catalogued on the web site and circulated at no cost to those who request them at http://watercenter.montana.edu/lending_library/.

Drinking Water Colloquium Proceedings

Montana Water 2005 calendar

Web site for the lending library at watercenter.montana.edu/lending_library/

POLICY REVIEW

In its capacity of funding research on Montana Water problems, our staff often serves as a liaison among the university community and water professionals and decision-makers in local, state, and tribal and federal governments. We often attend meetings of the Montana Legislative Environmental Quality Council, the Montana Watershed Coordination Council, the Watershed Activities Work Group and others, with the goal of offering research support when needed. As appropriate, we collaborate with other water centers to develp and forward policy recommendations at the national level.

THE MONTANA WATERCOURSE

The Montana Watercourse, founded in 1989, has come full circle. When it was first established as a partnership between the Department of Natural Resources and Conservation and Montana State University, it was housed in the Water Center. After 16 years and many changes for both programs, Montana Watercourse is once again joining the Water Center, thus linking the Watercourse's public-education emphasis with Water Center programs focusing on basic research and technical support. The mission of the Montana Watercourse is *to foster lifelong stewardship of Montana's water by providing unbiased information, education, resources, and tools to all water users*. Its major programs are:

- *Know Your Watershed*. Montana Watercourse helps local stakeholders develop workshops to bring a common understanding of the major resource, economic, and social issues in their watershed. It also gives all parties a chance to discover common interests. The *Know Your Watershed* program has often been a significant catalyst for local action.

Facititator training.

- *Landowner and Local Stewardship*. Water resource topics tend to be technical, jargon-laden and complex. Local governments and landowners can have great difficulty sorting out the important information and understanding the impacts, even if they already understand the importance of water. Because different water issues are universal, but the particulars can vary greatly, tailored programs to suit different needs have been a signature of Montana Watercourse's efforts. Projects have included water rights workshops, wetland stewardship workshops, water-resource publications, and trainings for watershed groups, conservation districts, realtors, and local governments.

Two publications of the Watercourse.

- *Educator Training and Support*. Using Project WET, Aquatic WILD and other curricula, Montana Watercourse develops and delivers workshops for formal and informal educational instructors across the state. We offer teacher training, mini-grants and list serves to teachers statewide. Also, we offer graduate level teacher education courses focusing on area watersheds and water resources, giving educators a tool to make place-based education come alive.

Milk River tour.

Volunteer monitoring on the Gallatin River.

- *Volunteer Monitoring*. Many communities are interested in knowing more about water quality and how it might be affected by local actions. Volunteer monitoring can be an important tool; the Montana Watercourse has been assisting communities build volunteer monitoring programs since 1996. The Watercourse also brings this program to Montana schools, offering customized trainings, a database for sharing information, and a yearly Water Summit for advanced students and their teachers to share knowledge and learn about other monitoring efforts statewide.

- *Watershed Festivals and School Outreach*. Each year, Montana Watercourse supports watershed and wetland festivals at schools, giving grade school children an exciting opportunity to interact with experts and perform hands-on learning. Watercourse personnel also serve as judges in some regional science fairs. Each year, the Watercourse honors a water teacher of the year.

"Make a Splash" Festival.

In operation since the summer of 1997, the Wild Trout Research Lab has been busy this year supporting resident whirling disease research. It housed Yellowstone project fish for Montana State University and the National Park Service, and held over 90 tanks of whirling disease-exposed fish for Montana Fish, Wildlife and Parks. It continued to maintain whirling disease spore-fish and provide them to researchers on demand. Recent recipients include Dr. Billie Kerans of Montana State University, Dr. Todd Koel of Yellowstone Park, Beth MacConnell of the USFWS Bozeman Fish Health Center, and Dr. Bill Granath of the University of Montana. The lab hosted culture systems for the endangered Bliss Rapids snail, and multiple experimental apparatuses for MSU Ecology Department graduate students.

We conducted two projects to bolster the lab's facilities this year. An emergency generator capable of powering all the lab systems has just been installed. In addition, an engineering contractor developed plans for a major renovation of the lab. The purpose of the renovation is to make the lab useful to a much broader array of clients than it currently serves. In the future, the lab will host whirling disease work, as well as experiments on other fishery-management issues, and possibly other fish diseases.

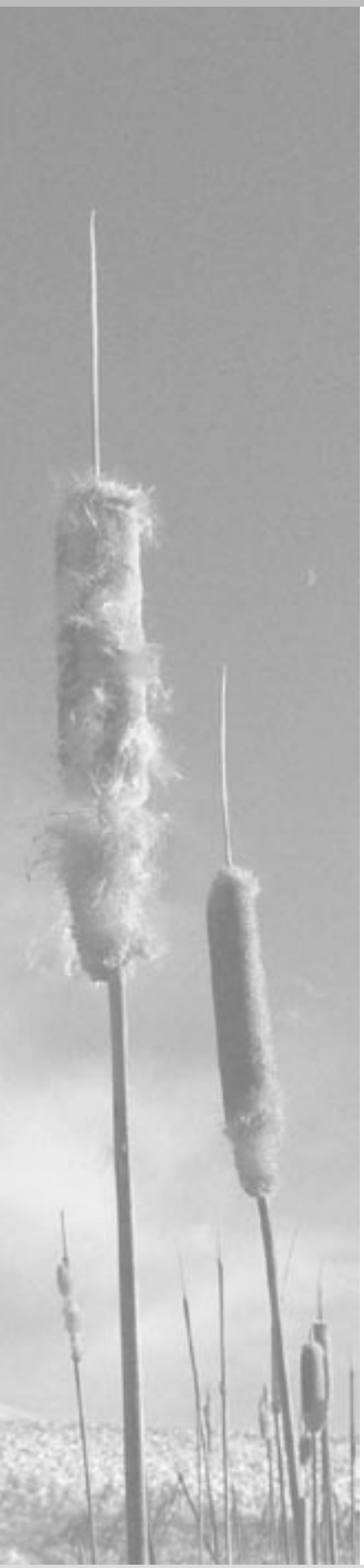
At the end of this year we were sad to say goodbye to the Center's first and only Lab Manager, Cal Fraser. Trey Kucherka has been hired as the new manager; he took up his post in September 2005. Once he gets his feet under him, it will be Trey's responsibility to oversee the lab renovation, making it ready for the new, 2006 research-season projects.

Cal Fraser

Trey Kucherka

Lab technician at work.

Advisory Committees



Water Research Advisory Committee
Bob Logar, Montana Department of Agriculture
Dave Feldman, Montana Department of Environmental Quality
Bob Davis, U.S. Geological Survey
Larry Dolan, Montana Department of Natural Resources and Conservation
Marvin Miller, Montana Tech
Tom Pick, USDA Natural Resources Conservation Service
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Krista Lee Evans, Legislative Environmental Quality Council

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Montana State University Campus and the Gallatin Valley.
Photo courtesy of Rick Jackson.